Faces and Places: Exploring Portability in Immersive Technologies

Policy Brief by Joseph Jerome[1]

When Mark Zuckerberg christened Meta in October 2021, his founder's letter highlighted that the future metaverse would need to be built upon open standards and interoperability. This was an optimistic vision with many hurdles to overcome, though the World Economic Forum expanded on the theme of interoperability in the metaverse to argue that interoperability would present enormous opportunities for "frictionless experiences, development, and economies."[2] The idea was that immersive technologies by their very nature would resist walled gardens; visions for the future of the web, web3.0, would be decentralized, user-centric, and less dependent on siloed platforms and hardware. Nick Clegg, Meta's President of Global Affairs, provided some further detail in a 2022 essay that described interoperability in the context of allowing technologies like virtual reality (VR) headsets and augmented reality (AR) glasses to interact together.[3]

We are a long way from an open and interoperable metaverse, let alone having mixed reality experiences that seamlessly cross competing headsets.[4] However, the development of immersive technologies like AR/VR provides a new opportunity for platform providers, creators, and other policy stakeholders to think about where to build data portability into these technologies before the metaverse is more fully baked. This policy brief provides (1) an overview of immersive technologies and (2) existing data portability law and policy and looks at (3) two use cases involving or adjacent to immersive technologies – spatial maps and avatars – as areas where data portability should be explored and enabled.

I. Understanding Data in Immersive Technologies

Immersive technologies have the potential to radically transform how we interact with the world and one another.[5] Immersive technologies generally refer to a cluster of technologies that enable different forms of extended reality (XR), which includes both augmented reality (AR) and

[1] Joseph Jerome is a visiting assistant professor of communications at the University of Tampa. He is also a privacy lawyer who previously worked on AR/VR policy with Meta Reality Labs.
[2] World Economic Forum, Interoperability in the Metaverse (2023), https://www.weforum.org/publications/interoperability-in-the-metaverse/.
[3] Nick Clegg, *Ensuring an Open and Interoperable Metaverse*, Meta (May 18, 2022), https://about.fb.com/news/2022/05/ensuring-an-open-and-interoperable-metaverse/.
[4] Adi Robertson, *The Vision Pro is a computer for the age of walled gardens*, The Verge (Jan. 31, 2024), https://www.theverge.com/24055677/apple-vision-pro-epic-netflix-app-ecosystem-monopoly.
[5] *See* XR Association, *XR at a Glance*, https://xra.org/xr-at-a-glance/ (last visited Feb. 1, 2024).

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

virtual reality (VR).[6] These technologies are distinct from other metaverse-enabling technologies like blockchain, generative AI, or NFTs and other types of digital assets; they also present different policy challenges and opportunities.

At a high level, VR environments are simulacra.[7] Virtual reality facilitates the construction of worlds that may or may not have any resemblance to a real-world space. In contrast, AR – and other intermediate states called mixed reality (MR) – involves the generation of digital content or virtual objects that can interact with and respond to the real world.[8] There are hybrid approaches, too. We see this now when developers endeavor to enhance the experience of VR headsets by situating them in real-world space using cameras and other sensors to create virtual experiences that rely on references to real-world space.[9]

The sheer scale of data collection needed to power these experiences is well documented.[10] Much of this information is the type of account data already common on social media; the Meta Quest 2 VR headset, for example, processes information about the headset user's profile, apps and app achievements, device settings and preferences, and social connections.[11] VR headsets can also generate a tremendous amount of device-level telemetry about hardware and software performance, as well as technical information like device identifiers and IP addresses.

---

[6] *See e.g.*, IEEE Digital Reality, Definitions and Characteristics of Augmented and Virtual Reality Technologies CTA-2069, https://digitalreality.ieee.org/standards. *See also* The XRSI Definitions of Extended Reality (XR), XR Safety Initiative Standard Publication XR-001, XR Safety Initiative (Mar. 2020), *available at* https://www.xrsi.org/publication/the-xrsi-definitions-of-extended-reality-xr.

[7] Joseph Jerome & Cobun Zweifel-Keegan, Achieving Congruence between New Tech and Old Norms: A Privacy Case Study of Spatial Mapping Tech in XR (2023 Working Draft), *available at* https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4733032.

[8] *Mixed reality*, XRSI Taxonomy of XR, https://xrsi.org/definition/mixed-reality-mr (last visited July 1, 2023).

[9] Hannah Ellis-Petersen, *Mat Collishaw restages 1839 photography show in virtual reality*, The Guardian (Apr. 14, 2017), https://www.theguardian.com/technology/2017/apr/14/somerset-house-mat-collishaw-restages-1839-photography-show-in-virtual-reality.

[10] Matthew Finnegan, *As VR headset adoption grows, privacy issues could emerge*, Computerworld (Aug. 14, 2023), https://www.computerworld.com/article/3704730/vr-headsets-can-create-a-privacy-headache.html. *See also* Vivek Nair, et al., Unique Identification of 50,000+ Virtual Reality Users from Head & Hand Motion Data (Feb. 17, 2023), https://arxiv.org/abs/2302.08927; Suchismita Pahi & Calli Schroeder, *Extended Privacy for Extended Reality: XR Technology Has 99 Problems and Privacy is Several of Them*, 4 Notre Dame J. Emerging Tech. (2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4202913; Caroline Louveaux & Derek Ho, When your data controller is Snoop Dogg, Mastercard (May 3, 2022), https://www.mastercard.com/news/perspectives/2022/metaverse-privacy-data-collection-nft/; Ellysse Dick, Balancing User Privacy and Innovation in Augmented and Virtual Reality, ITIF (Mar. 4, 2021), https://itif.org/publications/2021/03/04/balancing-user-privacy-and-innovation-augmented-and-virtual-reality/; Jeremy Bailenson, *Opinion: Protecting Nonverbal Data Tracked in Virtual Reality*, JAMA Pediatrics (Aug. 6, 2018), https://stanfordvr.com/mm/2018/08/bailenson-jamap-protecting-nonverbal.pdf.

[11] Ben Lang, Where to Change Quest 2 Privacy Settings and See What VR Data Meta Collects, Road to VR (July 25, 2022), https://www.roadtovr.com/oculus-quest-2-privacy-facebook-data-collection-settings/. One major challenge with describing device user controls is that settings are constantly in flux, and options available for Quest users have changed significantly over the past five years.

Electronic copy available at: https://ssrn.com/abstract=4739199

What is fundamentally unique about AR and VR technologies is their reliance on always-on sensors.[12] This includes two key types of sensors:

- Inward-facing sensors: Cameras that capture images of users' eyes and facial movements to power new device inputs, performance gains, and facilitate more natural virtual interactions.
- Outward-facing sensors: Cameras, as well as motion and depth sensors, and IMUs collect information about a device's immediate physical environment, as well as additional information about a user's physical movements or appearance.

These twin sensor streams are important to allow AR and VR technologies to offer immersive experiences and embodied experiences.[13]

Thus far, much of the policy discussion and privacy research on XR has emphasized what sensor data can reveal about users' bodies.[14] Commentators have alternatively referred to this sort of body-based data as biometric psychography or biometrically-inferred data,[15] and emerging regulatory proposals classify this information as sensitive "biological" data.[16] Whatever it is termed, this sensor information is necessary for improving social presence by facilitating more lifelike and realistic digital avatars.[17] Sensors on the Apple Vision Pro, for example, power a beta-version of what the company is calling "personas" for use in in-headset FaceTime calls.[18] More advanced and photorealistic avatar technology has been demonstrated by Meta via a casual interview between Mark Zuckerburg and tech commentator Lex Fridman, using the sensors on current Meta Quest Pro headsets to drive their bespoke avatars.[19]

---

[12] XRSI defines "XR Data" to specifically address the importance of "sensor data" for facilitating "presence, persistence, and immersion." *XR Data*, XRSI Taxonomy of XR, https://xrsi.org/definition/xr-data (last visited Jan. 1, 2024).

[13] For a discussion of the difference between immersion and embodiment, please see Pierre-Henry Leveau, *Embodiment, immersion, and enjoyment in virtual reality marketing experiences*, Psychology & Marketing, vol. 40, issue 7 pps. 1263-1445 (July 2023), https://onlinelibrary.wiley.com/doi/full/10.1002/mar.21822

[14] *See, e.g.,* Vivek Nair, et al., Unique Identification of 50,000+ Virtual Reality Users from Head & Hand Motion Data (Feb. 17, 2023), https://arxiv.org/abs/2302.08927; Jeremy Bailenson, *Opinion: Protecting Nonverbal Data Tracked in Virtual Reality*, JAMA Pediatrics (Aug. 6, 2018), https://stanfordvr.com/mm/2018/08/bailenson-jamap-protecting-nonverbal.pdf.

[15] *Compare* Brittan Heller, *Watching Androids Dream of Electric Sheep: Immersive Technology, Biometric Psychography, and the Law*, 23 Vanderbilt J. of Ent. & Tech. Law 1 (2021) *with Biometrically inferred data* (BID), XRSI Taxonomy of XR, https://xrsi.org/definition/biometrically-inferred-data-bid (last visited Jan 1, 2024).

[16] Protect Privacy of Biological Data, HB 24-1058 (2024), https://leg.colorado.gov/bills/hb24-1058.

[17] Daniel Berrick & Jameson Spivack, *Understanding Extended Reality Technology & Data Flows: XR Function*, Future of Privacy Forum (Oct. 31, 2022), https://fpf.org/blog/understanding-extended-reality-technology-data-flows-xr-functions/.

[18] Mark Spoonauer, *I just did my first Apple Vision Pro Zoom call using my Persona — and yikes!*, Tom's Guide (Feb. 1, 2024), https://www.tomsguide.com/computing/smart-glasses/apple-vision-pro-we-need-to-talk-about-personas.

[19] A good summary of the PR stunt is available from David Heaney, *Mark Zuckerberg Was Interviewed In VR With Prototype Photorealistic Avatars*, UploadVR (Sept. 28, 2023), https://www.uploadvr.com/mark-zuckerberg-lex-fridman-interview-photorealistic-codec-avatars/.

Electronic copy available at: https://ssrn.com/abstract=4739199

While camera scans and inward-facing sensors are important for driving embodiment and improved telepresence, outward-facing sensor data is essential to power MR use cases and the development of what has been called spatial computing.[20] Spatial computing envisions devices that understand real-world space. Spatial maps are constructed using many different types of spatial data. Spatial data comes in different forms, with different levels of fidelity and detail.[21] Some representations are very abstract, while other forms of spatial data reveal the layout of a room and the shapes of furniture. One day, spatial technologies will reproduce something akin to a 3D photorealistic digital recreation of our environment. A number of companies are building spatial mapping solutions, including the Overture Maps Foundation led by Amazon, Meta, and Microsoft[22] and the Open AR Cloud Association, that aspire to provide open and interoperable map data.[23]

Efforts to promote standardization and interoperability for immersive technologies are significant. The Metaverse Standards Forum, for instance, was established in 2022 to increase coordination and collaboration among standards-bodies like the World Wide Web Consortium (W3C) and industry to accelerate progress toward an "open and inclusive metaverse."[24] Active working groups include efforts to establish "a standardized character/avatar file format that can be dynamically loaded in multiple run times while maintaining consistent appearance, behaviors and animations" and to promote real/virtual world integration.[25] This policy brief intends to build on these technical efforts by adding a policy gloss on what this data means for portability more generally.[26]

II. Data Portability Rules

The application and utility of data portability to these sensor data streams is complicated by differing technical and legal understandings of what may be required and is feasible. Data portability refers generally to the ability of a user to extract data they have provided or stored with an online service in a structured, commonly used, and machine-readable format and transfer that data to a different service of the user's choosing.[27] Portability often goes

[20] Andrew Bosworth, Living in the Future, Meta (Dec. 18, 2023), https://about.fb.com/news/2023/12/metas-2023-progress-in-ai-and-mixed-reality/; *see also* Jerome & Zweifel-Keegan, *supra* note 7.
[21] MagicLeap provides the most approachable summary of different spatial mapping technologies. *See What is Spatial Mapping?*, Magic Leap, https://resources.magicleap.com/en-us/privacy/spatial-mapping-overview-and-detail-options (last visited Feb. 1, 2024). Other developer-facing primers are available from Microsoft and Meta.
[22] Overture Maps Foundation, *available at* https://overturemaps.org/.
[23] Open AR Cloud, *available at* https://www.openarcloud.org/.
[24] Metaverse Standards Forum, *available at* https://metaverse-standards.org/.
[25] *Id.*
[26] Jerome & Zweifel-Keegan, *supra* note 7; Joseph Jerome, *Pretty Soon, Your VR Headset Will Know Exactly What Your Bedroom Looks Like*, Wired (Oct. 3, 2023), https://www.wired.com/story/virtual-reality-meta-wearables-privacy/.
[27] *See* Ross Schulman, A Tech Intro to Data Portability, OTI (June 15, 2018), https://www.newamerica.org/oti/blog/tech-intro-data-portability/.

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

hand-in-hand with information access mandates, which are more firmly established for regulated health and financial services.[28]

Consumer-focused portability rights have gained new momentum through Article 20 of the 2018 EU General Data Protection Regulation (GDPR)[29] and expanded by EU efforts like the Digital Markets Act[30] and the Data Act.[31] GDPR-esque portability requirements were also embraced by U.S. state privacy laws like the California Consumer Privacy Act (CCPA).[32] The CCPA's data portability requirements are related to individual access rights, and where *personal* information is provided electronically, the law requires that information be provided in a portable and readily-usable format.[33] This has been subsequently expanded to give consumers the right to request that a business transmit their personal information when technically feasible.

However, neither the GDPR nor U.S. state privacy laws provide a clear rationale for their portability requirements. One further consequence of tying data portability to a larger collection of individual rights within a larger privacy or data protection regime is that it may have limited data portability's ultimate impact or utility. As Gabriel Nicholas, a technologist at the Center for Democracy & Technology, has explained, data portability serves two goals: (1) give consumers access and ownership over their data and (2) encourage competition by allowing companies to build new platforms and products with existing data.[34] Because privacy laws like the GDPR and CCPA view data portability through the lens of giving users more agency over information, competition benefits are treated by policymakers as "a sort of free, bonus benefit" that companies are incentivized to undermine by prioritizing user privacy and security.[35] As early discussion of the GDPR described the situation, the "object of data portability is still unclear and

---

[28] *See, e.g.*, Robert Gellman, *The health record interoperability dilemma*, IAPP (Aug. 14, 2019), https://iapp.org/news/a/the-health-record-interoperability-dilemma/ (discussing new health access efforts by the Centers for Medicare & Medicaid Services and one by the Office of the National Coordinator for Health Information Technology); Press Release, *CFPB Kicks Off Personal Financial Data Rights Rulemaking* (Oct. 27, 2022), https://www.consumerfinance.gov/about-us/newsroom/cfpb-kicks-off-personal-financial-data-rights-rulemaking/ (The CFPB has explored portability requirements under Section 1033 of the Dodd-Frank Act).

[29] Article 20, Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

[30] Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (Digital Markets Act)

[31] Regulation of the European Parliament and of the Council on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act).

[32] Cal. Civ. Code § 1798.130(a)(3)(B)(iii).

[33] Cal. Civ. Code § 1798.130(a)(2)(A).

[34] Federal Trade Commission, Data to Go: An FTC Workshop on Data Portability, Transcript at 146-47 (Sept. 22, 2020), https://www.ftc.gov/system/files/documents/public_events/1568699/transcript-data-portability-workshop-final.pdf.

[35] *See* Gabriel Nicholas, The New Portability: Designing Portability with Competition in Mind * Engelberg Center on Innovation Law and Policy (Sept. 2020), https://www.law.nyu.edu/sites/default/files/The_New_Data_Portability.pdf.

Electronic copy available at: https://ssrn.com/abstract=4739199

likely to have a too restrictive interpretation" and "the efforts required towards the development of interoperable formats and interfaces to port data are minimum."[36]

For instance, the Article 29 Working Party, the predecessor to the European Data Protection Board, issued guidance explaining that portability applies to a narrower set of data than the information generally subject to the GDPR's data subject access rights. Specifically, the guidelines explain that portability applies only to personal data that is (1) processed through automated means, (2) processed based on consent or pursuant to contract, and (3) provided by the individual.[37] What data is "provided by" the individual was divided into: (1) data actively and knowingly provided by a person, and (2) "observed data" provided by virtue of the use of the service or device like traffic or location data.[38] The Article 29 Working Party excluded the arguably more valuable – and interesting – "inferred data" or "derived data" kept in a user profile because this data was ultimately created by an online service provider itself.[39]

In practice, the scale of data portability has been evaluated through more utilitarian lenses. For example, a Facebook (now Meta) white paper in 2019 asked whether there are cases where "the burden of making data portable outweighs the person's interest in exporting it."[40] The company also acknowledged at the time that requiring "observed data" portability should be considered in light of the burden this requirement might place on smaller service providers "[g]iven that portability is partly intended to encourage competition and the emergence of new services."[41]

Whatever the reason, portability is often approached with a conservative posture, which not only hampers portability efforts generally but may dampen portability's potential moving forward. The EU Data Act recognizes this state of affairs:

> In practice, not all data generated by connected products or related services are easily accessible to their users and there are often limited possibilities regarding the portability of data generated by products connected to the internet. Users are unable to obtain the

---

[36] Paul De Hert, Vagelis Papakonstantinou, Gianclaudio Malgieri, Laurent Beslay, Ignacio Sanchez, *The right to data portability in the GDPR: Towards user-centric interoperability of digital services*, Computer Law & Security Review, vol. 34, issue 2, pps. 193-203 (2018), https://doi.org/10.1016/j.clsr.2017.10.003.

[37] Article 29 WP, Guidelines on the right to data portability, 16/EN, WP 2042, rev01 (April 2017), https://ec.europa.eu/newsroom/article29/items/611233. It is beyond the scope of this paper to evaluate the legal basis by which immersive technology companies process data to enable spatial mapping or avatar creation, but companies will generally suggest these are optional features and users opt into their use, even if consent is not as explicit as should be required by the GDPR.

[38] *Id.* at 9-10.

[39] *Id.*

[40] Erin Egan, Data Portability and Privacy, Facebook (Sept. 2019), https://about.fb.com/wp-content/uploads/2020/02/data-portability-privacy-white-paper.pdf. Curiously, Meta asks whether being able to "export of a list of all the links you've clicked on Facebook within a certain period" would be useful, perhaps providing an early preview of Meta's recent "Link History" feature. *See* Thomas Germain, *Meet 'Link History,' Facebook's New Way to Track the Websites You Visit*, Gizmodo (Jan. 2, 2024), https://gizmodo.com/meet-link-history-facebook-s-new-way-to-track-the-we-1851134018.

[41] Egan, *supra* note 39, at 14.

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

> data necessary to make use of providers of repair and other services and businesses are unable to launch innovative, convenient and more efficient services. In many sectors, manufacturers are able to determine, through their control of the technical design of the connected products or related services, what data are generated and how they can be accessed, despite having no legal right to those data.[42]

This situation has also arguably necessitated more stringent data portability requirements under the EU Digital Markets Act for major platforms designed as "gatekeepers." It also mandates that gatekeepers provide "effective portability of data provided by the end user or generated through the activity of the end user."[43] What this could mean for specific immersive technologies like the Meta Quest VR headset, Apple's mixed reality Vision Quest Pro device, or future AR smart glasses is unclear, but there is no reason why these new data streams, body-based data, and spatial information should be excluded from portability mandates.

Portability proponents should encourage data portability to be baked into immersive technologies from the start. VR headsets are in some respects already a mature technology, but as companies race to build and improve avatars, maps, and virtual content, ensuring these features are portable offers potential benefits to users and may unlock a larger push for interoperability.

III. Exploring Portability in Spatial Maps and Avatars

Portability in immersive technologies is nascent. An average user will find it difficult to move any of their information across different platforms and services purporting to be building toward the metaverse. Meta offers downloadable access to a subset of user information processed by Quest devices as a `.json` file, but this information lacks most, if not all, of the sensor streams unique to immersive technologies. Other major VR platforms lack device-specific privacy policies that even describe how users can exercise their access and portability rights.

The scaffolding to expand portability exists for immersive technologies. Interoperable 3D file formats are already in use by immersive technology platforms.[44] Two formats, Graphics Language Transmission Format (glTF) and Universal Scene Description (USD), are being developed by different industry consortia to support sharing three-dimensional scenes and models. glTF is a royalty-free specification developed by the Khronos Group,[45] which also spearheads the Metaverse Standards Forum, and has been called a JPEG for the metaverse.

[42] Regulation of the European Parliament and of the Council on harmonised rules on fair access to and use of data and amending Regulation (EU) 2017/2394 and Directive (EU) 2020/1828 (Data Act), at p. 19.
[43] Article 6(9), Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (Digital Markets Act). The regulation envisions that such portability "complements the right to data portability under the [GDPR]."
[44] 3D Asset Interoperability using USD and glTF Domain Exploratory Group Proposal, Metaverse Standards Forum, *available at* https://portal.metaverse-standards.org/document/dl/5010.
[45] glTF Overview, *available at* https://www.khronos.org/gltf/ (last visited Jan. 1, 2024).

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

USD is a competing or complementary (as the Khronos Group describes it) file format for storing and exchanging 3D assets,[46] and Apple, NVIDIA, and others have recently announced efforts to standardize the USD format.[47]

These formats facilitate the creation of spatial maps, digital avatars, and other content that goes hand-in-hand with immersive technologies. Ready Player Me, for instance, gives users the ability to download a `.glb` file of their avatar, which is a binary form of the glTF file, while Magic Leap allows headset users to download `.usdz` files of maps stored on device.[48] The issue is that access to these files is not consistent across the industry, and an average user cannot expect to have easy access to the files generated by their use of spatial mapping or avatar creation tools.

A. Use Case I: Spatial Maps

The next generation of computing devices will understand their environments in far more detail than they have in the past. Immersive technologies will, in the words of metaverse evangelist Cathy Hackl, "understand the wearer and their physical space, which in turn becomes updatable and interactive in real time"[49] due to sensor data streams, computer vision technologies, and artificial intelligence. A report from the Institute of Electrical and Electronics Engineers (IEEE) noted that industry-standard AR APIs and services contain different capabilities for "topological mapping, scene understanding, world positioning and geometric capture" like capturing and understanding physical space in real-time.[50] Underlying all of this magic, however, is a digital map – or rather, several mapping layers.

Spatial maps are essential for convincing and realistic mixed reality experiences. As Meta explains, different types of mapping data are necessary for different MR use cases.[51] At one end of the spectrum are more abstract point clouds, which consist of data points that represent the 3D coordinates of objects or surfaces in a physical space; at the other end are more detailed polygonal meshes of the immediate environment or semantic labels of objects, walls, and

[46] George Lawton, Why glTF is the JPEG for the metaverse and digital twins, Venture Beat (May 11, 2022), https://venturebeat.com/technology/why-gltf-is-the-jpeg-for-the-metaverse-and-digital-twins/.
[47] Press Release, *Pixar, Adobe, Apple, Autodesk, and NVIDIA Form Alliance for OpenUSD to Drive Open Standards for 3D Content*, Linux Foundation (Aug. 1, 2023), https://www.linuxfoundation.org/press/announcing-alliance-for-open-usd-aousd.
[48] AR Cloud, Magic Leap https://www.magicleap.care/hc/en-us/articles/9312806819597-AR-Cloud (last visited Jan. 1, 2024).
[49] Cathy Hackl, *What Is Spatial Computing?* LinkedIn Pulse (Jan. 18, 2024), https://www.linkedin.com/pulse/what-spatial-computing-cathy-hackl-pryde/.
[50] *Extended Reality (XR) and the Erosion of Anonymity and Privacy* 14, IEEE (2022), https://standards.ieee.org/wp-content/uploads/import/governance/iccom/extended-reality-anonymity-privacy.pdf.
[51] Meta, Responsibly Powering Mixed Reality Experiences on Quest 3 (Sept. 2023), *available at* https://about.meta.com/responsibly-powering-mixed-reality-experiences-on-meta-quest-3/.

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

surfaces.[52] Magic Leap has authored several primers where it offers visual representations of point clouds, dense meshes, and object recognition as follows:[53]

These different mapping layers are used to place virtual objects in space, occlude[54] virtual objects behind walls or real objects, give virtual environments proper physics and depth, and facilitate real and virtual navigation.[55] Spatial maps are also a necessary foundation to allow devices to be co-located in space. For example, a shared spatial map would permit multiple devices – and users – to see and interact with the same virtual content in the same co-located physical space. The Metaverse Standards Forum's Real/Virtual Integration Working Group has highlighted an immersive ride-hailing experience as an example.[56] Imagine both a rider and a driver rendezvousing in a dense urban area with the help of fully three-dimensional virtual signage that rotates and scales in synchronization until a pickup has been achieved. Conceptually, this seems like an easy feat, but it requires centimeter-accurate maps.[57]

Niantic, the developer of popular AR-game Pokémon Go, describes the company's efforts to create an AR map as "like GPS for the virtual version of the outside world, only far more precise,

---

[52] Jerome & Zweifel-Keegan, *supra* note 7.
[53] *Spatial Mapping for Magic Leap 1*, Magic Leap, https://www.magicleap.com/spatial-mapping-ml1#spatial-mapping (last updated June 13, 2022).
[54] Occlusion in mixed reality is the ability to cover virtual objects with real objects physically located in the room. In other words, a person could walk in front of a virtual screen or a virtual object could roll behind a couch.
[55] *Spatial mapping*, Microsoft https://learn.microsoft.com/en-us/windows/mixed-reality/design/spatial-mapping (last updated Jan. 31, 2023); *see also* Manorama Jha, *Facing the Engineering Reality of Mixed Reality with Intel AI* (Dec. 20, 2019), https://manoramajha.medium.com/facing-the-engineering-reality-of-mixed-reality-with-intel-ai-e062711ce876.
[56] Metaverse Standards Forum, Real/Virtual World Integration Working Group, *Use Case 1 (UC1) - Ride-Hailing: Assisted Car-Human Urban Rendezvous*, https://github.com/MetaverseStandards/Virtual-Real-Integration/blob/main/src/UC1/readme.md (last visited Jan. 1, 2024).
[57] Peter Ondruska, Blue Vision Labs is joining Lyft!, Blue Vision Labs (Oct. 23, 2018), https://medium.com/@bluevisionlabs/blue-vision-labs-is-joining-lyft-657daca89b71.

Feb 2024 Draft
Electronic copy available at: https://ssrn.com/abstract=4739199

down to the centimeter."[58] In practice, robust spatial data applications are roughly analogous to existing understandings of geolocation data, but at much higher levels of precision and detail. These spatial maps are often built via users contributing their own spatial data to the project. Pokémon Go includes an optional feature known as "PokéStop Scanning" that allows users to record an image stream as well as telephone metadata to generate a dynamic 3D map of the real world.[59]

Magic Leap, for instance, offered a "Shared World" feature on its Magic Leap 1 device that allowed users to contribute to a collective spatial map stored on the company's cloud. Opting into "Shared World" meant that a user's AR device need not map a new area if other Shared World users had previously mapped an area; it also allowed different users to see the same digital content in the same physical location.[60] For the Magic Leap 2 device, an enterprise-level AR Cloud was introduced, which allowed users to download map scans in either `.map` and `.usdz` file formats to help users with troubleshooting, comparing maps between devices, and import/export operations for third-party apps.[61] Some of this information can be made usable for developers. For example, Unity-based developers on the Meta Quest platform are also exploring how to duplicate and manipulate meshes of physical space.[62]

Access to and portability of spatial data will become more important as AR technologies and mixed reality develops. One major tension point is that platforms may try to treat spatial maps as user-generated content (UGC), ensuring that spatial data contributed by users in violation of property rights, contractual rules, or safety requirements is not their responsibility. This position is especially problematic even as it will be platforms and developers that independently seek to gather and combine spatial data to fuel contextual AI features.[63] Mapping portability may help to spur competition and, potentially, force platforms to be more responsible stewards of the spatial data they solicit.

Feb 2024 Draft

---

[58] *Lightship VPS: Engineering the World's Most Dynamic 3D AR Map*, Niantic (Sept. 28, 2022), https://nianticlabs.com/news/engineering-the-worlds-most-dynamic-3d-ar-map?hl=en.

[59] *Scanning a PokéStop*, Pokémon GO Help Center, https://niantic.helpshift.com/hc/en/6-pokemon-go/faq/2519-scanning-a-pokestop/ (last visited Jan. 1, 2024).

[60] *Spatial Mapping for Magic Leap 1*, Magic Leap, https://www.magicleap.com/spatial-mapping-ml1#spatial-mapping (last updated June 13, 2022).

[61] AR Cloud, Magic Leap https://www.magicleap.care/hc/en-us/articles/9312806819597-AR-Cloud (last visited Jan. 1, 2024).

[62] *See* Unity MR Starter For Quest, GitHub, https://github.com/TakashiYoshinaga/UnityMRStarterForQuest/tree/main (last visited Feb. 18, 2024).

[63] *See* Meta Reality Labs, *Inside Facebook Reality Labs: Research updates and the future of social connection* (Sept. 25, 2019), https://tech.facebook.com/reality-labs/2019/9/inside-facebook-reality-labs-research-updates-and-the-future-of-social-connection/ (describing the company's LiveMaps effort as giving users the ability "to search and share real-time information about the physical world. This will enable a powerful assistant to bring you personalized information tied to where you are, instantaneously. It will also give you an overlay that will allow you to anchor virtual content in the real world.").

Electronic copy available at: https://ssrn.com/abstract=4739199

B. Use Case II: Avatars

Another portability use case is the data that make up an individual's digital avatar. A digital avatar is a computer-generated representation of a person, and they are used to create personalized experiences and to represent users in virtual environments. Avatars are not a new concept in computing,[64] and have been a frequent staple of online gaming, but the concept has special salience for immersive technologies.

The term was famously popularized in Neal Stephenson's *Snow Crash*, the novel which also originated the term "metaverse."[65] Avatars take on increased importance in virtual environments and immersive technologies and have been described as offering a "new layer of representation and self-expression" for the metaverse.[66] Avatars fall on a spectrum of visual styles graphical fidelity from realistic to stylized, which can either be a technical limitation or by design based on the seriousness of the experience. Companies have demonstrated ambitious roadmaps for realistic avatars, such as Meta with its codec avatars project, Epic's digital metahumans,[67] or Apple's realistic avatars for FaceTime,[68] and a major reason so many firms are building avatar solutions is because avatars may offer continuity of digital identity across apps, services, or immersive experiences.

Thus, avatars are inexorably intertwined with visions for an open and interoperable metaverse. Several companies are pushing the importance of avatars, promoting their own interoperability solutions. Meta, for instance, offers an Avatars SDK so third parties can bring Meta Avatars into their apps. Ready Player Me, which also provides a centralized Avatars API service for interoperable avatars, has been more outspoken about the growing role of digital avatars:

> The avatar is your identity. It's the persistent part of any social virtual experience. You need to have an avatar in any 3D world that you visit. The avatar is a representation of yourself. So why should you create an avatar each time from scratch that looks and feels different, that doesn't represent your overall identity? At some point we understood that the avatar can be the glue or the link between all those different things.[69]

---

[64] *Avatar (computing)*, Wikipedia, https://en.wikipedia.org/wiki/Avatar_(computing) (last visited Jan. 1, 2024).
[65] Thom Waite, *Snow Crash: the 30-year-old novel that predicted today's twisted Metaverse*, Dazed (Dec. 9, 2022), https://www.dazeddigital.com/life-culture/article/57745/1/snow-crash-30-year-old-novel-predicted-todays-twisted-metaverse-neal-stephenson.
[66] Meta has discussed the importance of avatars in several external presentations. See, for example, Ellysse Dick's 2022 AWE presentation, *Identity & Self-Expression in the Metaverse*. More information available at https://www.awexr.com/usa-2022/agenda/2939-identity-self-expression-in-the-metaverse.
[67] *See* Unreal, *Metahuman: High-fidelity digital humans made easy*, https://www.unrealengine.com/en-US/metahuman (last visited Jan. 1, 2024).
[68] Emma Roth, *Apple's Vision Pro headset will turn you into a digital avatar when FaceTiming*, The Verge (June 5, 2023), https://www.theverge.com/2023/6/5/23750096/apple-vision-pro-headset-persona-facetime.
[69] Dean Takahashi, *Will interoperable avatars be essential for the open metaverse? | Timmu Tõke*, Venture Beat (April 2, 2023),

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

This vision for avatars highlights some of today's real limitations, however. The repetition and inconvenience of constantly building new digital avatars is a known problem, and companies have turned to using selfies or visual scans as a solution to auto-generate a base avatar.[70] Early avatars could be generated from a limited menu of options, but as functionality has expanded, the base number of avatars that can often be generated can be nearly limitless.[71]

The number of unique parameters makes full interoperability across avatar platforms difficult, but even efforts at basic portability are lacking. Meta provides an illustrative example. While the company provides extensive data portability tools for its apps[72] and offers Quest-specific data downloads, it currently provides only a `.png` file and a 2D representation of its Meta Quest avatars.

Avatar 2D image

2D representation of your avatar associated with your account

These are 2D images of the author's various Meta avatars that are currently available via Meta's Oculus data dashboard as of January 2024. A transparent `.png` of the image on the right is accessible through a Quest data download. This would appear to be the full extent of avatar access easily accessible to a Quest headset user.

It would seem possible to provide richer avatar files to users, and indeed, the scaffolding to expand avatar portability exists. glTF (Graphics Library Transmission Format) is a standard file format for three-dimensional scenes and models developed by the Khronos Group,[73] which also spearheads the Metaverse Standards Forum. The glTF specification and `.glb` file format are already in use by many avatar solutions, and users have taken it upon themselves to effectively port avatars across different games and platforms. Ready Player Me allows users to download a

https://venturebeat.com/games/will-interoperable-avatars-be-essential-for-the-open-metaverse-timmu-toke/.

[70] Facebook, *How Avatar AutoGen works and how Meta processes your AutoGen data*, https://www.facebook.com/help/276796764805785 (last visited Jan. 1, 2024).

[71] *See* Christopher Manning, Calculating Different Mii Combinations (Mar. 3, 2010) https://www.christophermanning.org/writing/calculating-different-mii-combinations (calculating that there are 88 vigintillion combinations of Miis).

[72] *Data Portability*, Meta, https://about.fb.com/news/tag/data-portability/ (last visited Jan. 1, 2024).

[73] *See* glTF Overview, *available at* https://www.khronos.org/gltf/ (last visited Jan. 1, 2024).

Electronic copy available at: https://ssrn.com/abstract=4739199

`.glb` file of their avatar, and users have demonstrated how to modify and export that avatar file for use in other VR games on the Meta Quest platform.[74]

Accessing an avatar's file is also not a new concept. When Nintendo released its Wii game console in 2006, it came with pre-installed software to build an array of "Mii" avatars which could be used as player characters in games ranging from Wii Sports to Mario Kart.[75] Additionally, Miis could be stored on a Wii remote controller,[76] and ultimately, users built their own homebrew Mii editors for the web. Many modern avatar solutions are more complex and at a higher visual fidelity, but conceptually, there is no reason that users should not have more access to the avatars they create.

Certainly, there are significant technical and policy challenges to more widespread portability. Different styles of representation designed for one platform may not visually fit another service's aesthetic or gameplay mechanics.[77] Imagine a stylized, cartoon-based avatar appearing in a more hyper-realistic environment. While this could be part of the creative appeal of the metaverse, this mismatch could also be addressed by standardizing certain avatar features or allowing for platform-specific adaptations. Nintendo did something similar when it used an updated version of its Mii file format to populate non-player characters in its recent Zelda titles, and the file formats are cross-compatible.[78]

There are also significant ethical and privacy challenges posed by allowing users to access and port more realistic representations of people.[79] Porting high-fidelity avatars across platforms presents serious risks of identity theft or unintentionally exposing personal characteristics, but for more basic, stylized avatars, it should be easier for users to reuse some subset of their avatar settings.

Feb 2024 Draft

[74] See this Reddit thread, Ready Player Me avatars?, for links and resources on how to use Ready Player Me avatars in the popular VR experience *Bonelab*: https://www.reddit.com/r/BONELAB/comments/ycwzsv/ready_player_me_avatars/ (last visited Jan. 1, 2024).
[75] *What Is a Mii?*, Nintendo, https://en-americas-support.nintendo.com/app/answers/detail/a_id/2544/~/what-is-a-mii%3F (last visited Jan. 1, 2024).
[76] *Mii Channel: Storing a Mii in Your Wii Remote*, Nintendo, https://www.nintendo.co.uk/Support/Wii/Wii-Channels/Mii-Channel/Mii-Channel-Storing-a-Mii-in-Your-Wii-Remote/Mii-Channel-Storing-a-Mii-in-Your-Wii-Remote-242309.html (last visited Jan. 1, 2024).
[77] Interoperable Characters / Avatars Education Session Highlights, Metaverse Standards Forum (Jan. 8, 2024 at 0:50/8:28) https://www.youtube.com/watch?v=r0wW7z8W18s&t=49s.
[78] Owen S. Good, *Breath of the Wild's NPCs are actually Miis, modder confirms*, Polygon (Jan. 5, 2021), https://www.polygon.com/2021/1/5/22215263/breath-of-the-wild-npcs-are-miis-nintendo-legend-of-zelda-switch.
[79] Samantha Cole & Emanuel Maiberg, *'They Can't Stop Us:' People Are Having Sex With 3D Avatars of Their Exes and Celebrities*, Vice (Nov. 19, 2019), https://www.vice.com/en/article/j5yzpk/they-cant-stop-us-people-are-having-sex-with-3d-avatars-of-their-exes-and-celebrities.

Electronic copy available at: https://ssrn.com/abstract=4739199

IV. Conclusion: The Case for Data Portability in Immersive Technologies

While avatars and spatial maps represent crucial components to new immersive technologies, they are merely early examples of the vast array of UGC that will fuel the adoption of a wider metaverse. Just like persistent maps and user representation, other forms of UGC – virtual objects, interactive scenes, even custom game modes – could thrive in a truly open and interoperable metaverse. However, if leading platforms opt for bespoke approaches to this basic functionality, users and developers will face the same challenges and lock-in issues that plague today's online and social media landscape.

Imagine a future where mixed reality experiences can seamlessly transition across devices, empowering users to continue tasks across different headsets and smartphones. Imagine, for example, an Apple Vision Pro user leaving a note in AR for a Meta Quest user – and that same note is visible via camera lens on iOS and Android phones. Some of these applications could be very silly, like an interactive digital bobblehead of a stylized avatar that sits on your desk for anyone to see and poke.[80] Other use cases may be more impactful:

- Users could personalize their immersive experiences across different devices and invite friends and colleagues into a digital duplicate of their real-world environment by sharing spatial maps. Individuals with disabilities could have their accessibility settings automatically adjusted depending on the physical space they are in. More robust access to mapping data could facilitate offloading compute from AR glasses and VR headsets.
- With more accessible and portable mapping data, users could potentially access more robust AR/VR experiences even without an internet connection. This could be vital for situations with limited connectivity or for enhancing safety in sensitive environments. For instance, firefighters could pre-download spatial maps of buildings for offline access during emergencies.
- Artists or developers could easily share and reuse spatial mapping data for virtual environments or augmented reality experiences. Developers could share intricate 3D maps to facilitate app development without recreating environments from scratch.

This policy brief has given short shrift to the myriad privacy, security, and standardization challenges that stand in the way of more robust portability, but immersive technology offers a potential fresh start for establishing common standards for data structure and exchange and to bake in robust authentication mechanisms and secure data protocols. The potential benefits are many.

Portability in the metaverse promises to reduce switching costs from the start, to promote personalization alongside a sense of agency and empowerment for users, and to allow

[80] Such an application is probably one of the easiest integrations of an avatar. See *Mii Bobblehead*, Wikitroid, *available at* https://metroid.fandom.com/wiki/Mii_Bobblehead (last visited Jan. 1, 2024).

Feb 2024 Draft

Electronic copy available at: https://ssrn.com/abstract=4739199

developers to better build on each other's work – and be less reliant on the whims and ambitions of larger immersive technology platforms. The alternative is to build toward a metaverse that may be far more lonely than anyone intends,[81] and that would seem to defeat the whole purpose of creating an embodied and immersive internet.

Feb 2024 Draft

[81] Allison Johnson, *Apple's view of the future is a lonely one*, The Verge (June 7, 2023), https://www.theverge.com/23751675/apple-vision-pro-vr-headset-ios-17-mental-health-mood-journal.

Electronic copy available at: https://ssrn.com/abstract=4739199